Air Resource Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, CO 80525
Phone: 970-484-7941
Fax: 970-484-3423

QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**CALIBRATION AND ROUTINE MAINTENANCE OF 2B TECHNOLOGIES, INC. MODEL 202 OZONE ANALYZERS**
TYPE	**TECHNICAL INSTRUCTION**
NUMBER	**3100-2005**
DATE	**MAY 2003**

AUTHORIZATIONS		
TITLE	NAME	SIGNATURE
ORIGINATOR	Mike Slate	
PROJECT MANAGER	John F. Faust	
PROGRAM MANAGER	David L. Dietrich	
QA MANAGER	Gloria S. Mercer	
OTHER		

REVISION HISTORY			
REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS
	Reviewed; no changes necessary.	May 2004	
	Reviewed; no changes necessary.	May 2005	
1.0	Change instrument adjustment statements/ multipoint concentration ranges /add scrubber conditioning text.	May 2006	
1.1	Change multipoint concentration ranges.	May 2007	

TABLE OF CONTENTS

LIST OF FIGURES

1.0 PURPOSE AND APPLICABILITY

The purpose of calibration and maintenance is to assure quality data capture and minimize data loss by performing and documenting scheduled operational checks and preventive maintenance. This technical instruction (TI) provides specific details for routine calibration and maintenance of 2B Technologies, Inc. Model 202 ozone analyzers. This TI is referenced in Standard Operating Procedure (SOP) 3100, *Calibration of Ambient Air Quality Analyzers*, and serves as a guideline to facilitate the following:

- Performing calibration checks
- Evaluating analyzer response
- Calibrating (adjusting) the analyzer
- Performing analyzer maintenance
- Replacing analyzer components

Calibrations (including multipoint, zero, and span) are required under any of the following circumstances:

- Upon acceptance testing of a new instrument
- Upon installation or removal of the instrument at a field station
- Whenever control limits are exceeded
- Prior to any corrective action, service, or maintenance to any portion of the instrument that affects its operational principle
- At a maximum interval of six months

Continuous gas analyzer calibrations will follow protocols as established by EPA/600/4-77/027a *Quality Assurance Handbook for Air Pollution Measurement System: Volume II,* and Appendix B of 40 CFR 58 *Quality Assurance Requirements for Prevention of Significant Deterioration (PSD) Air Monitoring*. All measurement devices and calibration standards will be traceable to the National Institute of Standards and Technology (NIST).

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Establish the project-specific calibration schedule and coordinate with the client as necessary.
- Establish the calibration reporting protocol to satisfy client requirements.
- Review calibration results.
- Identify inconsistencies in calibration results and initiate corrective action as required.

2.2 FIELD SPECIALIST

The field specialist shall:

- Perform required calibrations and maintenance as described in this TI.
- Verify that the calibration standards are in good working order and are in current calibration.
- Document all calibration results and maintenance procedures performed.

3.0 REQUIRED EQUIPMENT AND MATERIALS

The following equipment is required for ozone analyzer calibration:

- Digital voltmeter (DVM)
- Certified O_3 transfer standard or verified O_3 primary standard
- BIOS flow calibrator
- Zero air supply
- Clean Teflon tubing and fittings
- Canned, compressed air
- Methanol (ACS Reagent grade)
- Field service tools
- Personal protection (safety goggles, lab coat, rubber gloves)
- 2B instrument manual
- Station log book or DataView
- Ozone calibration forms
- Pen or pencil
- Laptop computer loaded with Excel spreadsheet form (OZONE.XLT) or CALIBRATIONS_EDITS.XLS program software
- Calibration stickers

Replacement parts may include:

- Ozone scrubber
- Glass wool

- Solenoid valve
- UV photometer lamp
- Sample or calibration pump

4.0 METHODS

The procedures described in this TI are specific to 2B Technologies analyzers. Calibration and maintenance include tasks are detailed in the following seven (7) subsections:

4.1 Preparation for Analyzer Calibration
4.2 Calibration Checks
4.3 Ozone Transfer Standard Preparation
4.4 Multipoint Calibration
4.5 Analyzer Maintenance
4.6 Post-Maintenance Calibration Checks
4.7 Documentation

4.1 PREPARATION FOR ANALYZER CALIBRATION

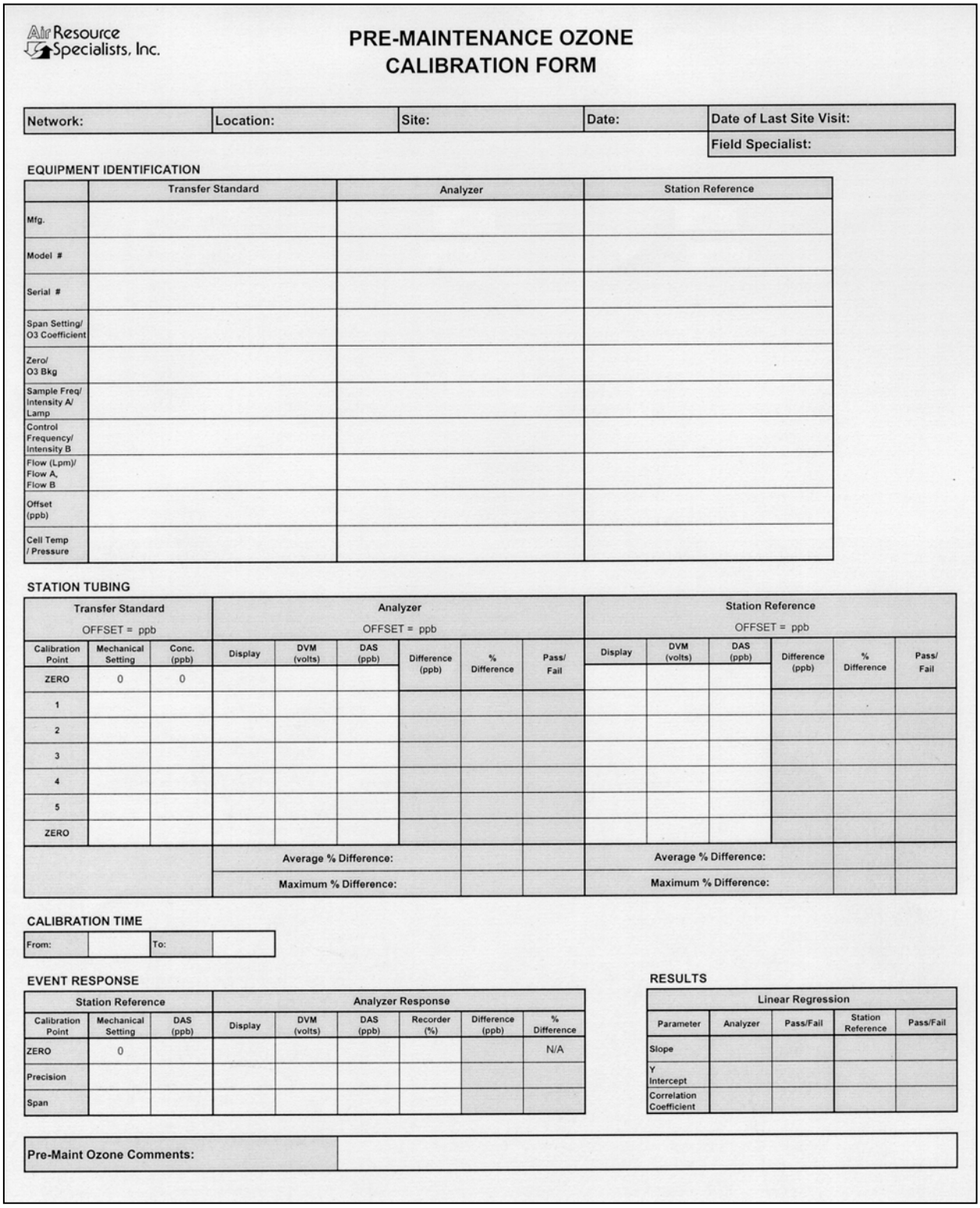
Before performing a calibration check, ensure adequate preparation of the operational environment, calibration device (transfer standard), and the analyzer by determining the following:

- The station is at the proper temperature.
- Instruments are adequately warmed up.
- Calibration documentation is current, complete, and available.
- All required support tools, diagnostic equipment, supplies, and calibration forms are available.

4.2 CALIBRATION CHECKS

A complete calibration check must be performed prior to (pre) and following (post) any maintenance activity. The calibration check procedures described below apply to both pre- or post-maintenance checks. Refer to Figure 4-1, Example Ozone Calibration Form, when performing calibration checks. Be sure to indicate on the form whether the calibration is pre- or post-maintenance and note all maintenance activities or replaced components in the “Comments” field. The form is available as an Excel spreadsheet and should be used at all times. Results of each calibration should be in both hardcopy and digital form.

Before introducing calibration gas into the analyzer, complete the following operational checks. Should any operational check be out of suggested tolerance, complete the calibration check before any maintenance or adjustments are made.



Air Resource Specialists, Inc.

PRE-MAINTENANCE OZONE CALIBRATION FORM

Network:	Location:	Site:	Date:	Date of Last Site Visit:
				Field Specialist:

EQUIPMENT IDENTIFICATION

	Transfer Standard	Analyzer	Station Reference
Mfg.			
Model #			
Serial #			
Span Setting/ O3 Coefficient			
Zero/ O3 Bkg			
Sample Freq/ Intensity A/ Lamp			
Control Frequency/ Intensity B			
Flow (Lpm)/ Flow A, Flow B			
Offset (ppb)			
Cell Temp / Pressure			

STATION TUBING

Transfer Standard OFFSET = ppb			Analyzer OFFSET = ppb						Station Reference OFFSET = ppb					
Calibration Point	Mechanical Setting	Conc. (ppb)	Display	DVM (volts)	DAS (ppb)	Difference (ppb)	% Difference	Pass/ Fail	Display	DVM (volts)	DAS (ppb)	Difference (ppb)	% Difference	Pass/ Fail
ZERO	0	0												
1														
2														
3														
4														
5														
ZERO														
			Average % Difference:						Average % Difference:					
			Maximum % Difference:						Maximum % Difference:					

CALIBRATION TIME

From:		To:	

EVENT RESPONSE

Station Reference			Analyzer Response					
Calibration Point	Mechanical Setting	DAS (ppb)	Display	DVM (volts)	DAS (ppb)	Recorder (%)	Difference (ppb)	% Difference
ZERO	0							N/A
Precision								
Span								

RESULTS

Linear Regression				
Parameter	Analyzer	Pass/Fail	Station Reference	Pass/Fail
Slope				
Y Intercept				
Correlation Coefficient				

Pre-Maint Ozone Comments:	

Figure 4-1. Example Ozone Calibration Form.

ANNOTATE DATA RECORDS

Make an entry in the station log book or DataView log and annotate the strip chart recorder (if present) and data acquisition system (DAS), indicating the date and time (beginning and ending) of the calibration and maintenance procedures. “Down” the appropriate channels on the DAS or set the calibration flag as appropriate for the DAS being used.

Complete the following fields on the Ozone Calibration Form: network and station name, current date, name of technician performing the calibration, serial number of the analyzer, date of the last calibration, and date of the last calibration and maintenance visit. Also complete information regarding model and serial numbers of the instruments to be calibrated.

PRESSURE / TEMPERATURE

During normal operation the display will alternate between the average ozone concentration and the real-time ozone concentration. The current pressure and temperature will be displayed simultaneously when the real-time ozone concentration is displayed. Record both values in the cell temperature column.

4.3 OZONE TRANSFER STANDARD PREPARATION

To prepare the ozone transfer standard (TECO 49CPS):

TURN ON

Turn the transfer standard on and allow it to warm up for at least one hour.

CONNECT ZERO AIR SUPPLY

Connect a zero air supply to the ZERO AIR inlet port.

CONNECT TEFLON TUBING

Connect a clean length of Teflon tubing from the OZONE port on the back of the TECO 49CPS to the inlet on the 2B analyzer. Leave the VENT port on the back of the TECO 49CPS open.

If two 2B analyzers will be calibrated simultaneously, use a tee on the Teflon tubing coming from the OZONE port and run separate lines from the tee to each of the 2B analyzers to be calibrated.

COMPLETE CHECKS

Complete and record the operational checks from the TECO 49CPS. Obtain flow, calibration parameters, frequencies, flows, temperatures, and pressures by manipulating the display menu and control buttons from the front of the TECO. Record values on the ozone calibration form. Consult the TECO 49C manual for specific directions in navigating through the onscreen display menu.

Ozone transfer standards are verified (re-certified) using similar methods as calibrating a photometer-based ozone analyzer. Refer to SOP 3300, *Certification of Ozone Transfer Standards*, for re-certification procedures.

4.4 MULTIPOINT CALIBRATION

The following subsections describe the steps of a five-point calibration check. Calibration of an instrument infers an adjustment to the instrument response after a calibration check.

4.4.1 Initiate Calibration

TURN ON

Turn on the zero air supply compressor.

Turn on the sample pump of the TECO 49CPS.

Press the **ENTER** button on the TECO 49CPS until LOCAL appears in the lower-right corner.

Press the **RUN** button on the TECO 49CPS until the display reads ZERO in the lower-left corner. The 2B should be operating and analyzing zero gas coming from the TECO.

ADJUST FLOW

Remove the cover from the TECO 49CPS. Check the pressure of the zero air supply coming from the compressor on the pressure gauge attached to the regulator in the center of the TECO 49CPS. The pressure should be 10 psi.

Adjust the regulator if necessary. This is an adequate pressure to supply excess calibration gas to two 2B analyzers and the TECO 49CPS.

Allow the instruments to stabilize and record the responses of both the transfer standard and the analyzer on the Ozone Calibration Form as described in Section 4.4.2.

GENERATE OZONE

The TECO 49CPS has four preset custom levels. These levels correspond to specific ozone concentrations as generated by the ozone lamp inside the TECO49CPS.

To change from one custom level to the next, press the **RUN** button. The custom level will be displayed with a question mark. If this is the desired concentration, press **ENTER**. If not, continue to press **RUN** until the desired custom level is displayed, then press **ENTER**. Because the multipoint calibration requires five different ozone concentrations and there are only four custom settings on the TECO 49CPS, one of the settings will need to be changed during the multipoint.

To change one of the custom concentration levels, press **ENTER** to bring up the MAIN MENU.

Scroll down to custom levels options and press **ENTER**. Settings of the four custom levels will appear on the display. To change the custom level settings, scroll down to the desired level to change. Press **ENTER**. The screen will display the current setting of that specific custom level.

GENERATE OZONE (continued)

To change the setting use the up and down arrows until the display shows the desired ozone concentration. Press **ENTER**. The screen will blink displaying SAVING PARAMETERS to indicate the change was successful.

Press **RUN** to return to the operate mode.

SCRUBBER CONDITIONING

Previous experience has shown the 2B scrubber needs time to be conditioned. To condition the scrubber, provide ozone calibration gas at 470 ppb for 1 hour to the 2B monitors being calibrated. After 1 hour, multipoint calibrations can occur.

Multipoint concentration ranges must include:

0 to 400 ppb range
0 ppb
400 ± 10 ppb
300 ± 10 ppb
200 ± 10 ppb
100 ± 5 ppb
50 ± 5 ppb

Allow the values to stabilize and record the responses of the transfer standard and ozone output on the Ozone Calibration Form as described below in Section 4.4.2.

Select additional ozone concentrations by manipulating the transfer standard ozone custom settings and record the analyzer and transfer standard responses on the Ozone Calibration Form.

4.4.2 Record and Evaluate Analyzer Response

The following steps must be performed while calibrating the analyzers:

RECORD ANALYZER RESPONSE

Allow the analyzer to fully respond and stabilize on each of the five introduced gas concentrations. If response fails to stabilize, abort the calibration check, investigate the problem, and take corrective action. After the analyzer response stabilizes, note and record the analyzer front panel display, analyzer voltage output, and data acquisition response on the calibration form (or laptop computer Excel spreadsheet) and on the strip chart.

CALCULATE Δ%

Review the percent difference (Δ%) between designated input and analyzer response calculated by the Excel calibration spreadsheet, or if not automatically calculated by the spreadsheet, calculate the percent difference (Δ%) with the following formula:

$$\%\,Difference = \frac{Analyzer\ \mathrm{Re}\ ponse - Designated\ \ Input}{Designated\ Input} x100$$

CALCULATE Δ% (continued)

Example:

$$\Delta\% = \frac{0.410\ ppm - 0.400\ ppm}{0.400\ ppm} x100 = 2.5\%$$

Note: Use the data acquisition system recorded response for the analyzer response.

AVERAGE Δ%'S

Average the Δ%'s for all concentrations. Make sure to retain the correct signs (+ or -) during the calculation. Do not include the zero values in the Δ% calculations.

REVIEW DATA

Review data to determine if analyzer adjustment (calibration) is required:

If the slope is <0.950 or >1.050, analyzer adjustment or repair is required.

If the intercept is >0.3 ppm, analyzer adjustment or repair is required.

If the correlation is <0.9950, analyzer adjustment or repair is required.

4.4.3 Calibrate (Adjust) Analyzer

To change the calibration parameters, select **CFG** from the MAIN MENU by double-clicking to bring up the CONFIGURATION MENU.

Cfg Menu
D/T Cal I/O Unt

Now double-click on **CAL**. The following submenu with the values of the current calibration parameters appear:

Cal Menu
Z= -2 S= 1.01

Here "Z" is the offset applied (in this case -2 ppbv) and "S" is the slope applied (in this case 1.01). The value of "Z" is added to the measured ozone value and the value of "S" is then multiplied by the measured ozone value. For example, if the instrument reads an average concentration of 3 ppbv with the zero air gas, the value of "Z" should be set to -3. If after correction for the zero, the instrument consistently reads 2% low, the value of "S" should be set to 1.02.

When the Cal Menu first appears, the cursor will be beneath the "Z." Single-clicks will change the value of "Z" in the range of -9 to 9. A double-click will move the cursor to lie beneath "S." Single-clicks will change the value of "S" in the range of 0.91 to 1.09. Additional double-clicks will move the cursor between "Z" and "S." Once the values of "Z" and "S" are set, a triple-click from any location will return the display to the Cfg Menu, and an additional triple-click will return to the MAIN MENU. The calibration parameters reside in non-volatile memory and are not affected by power failures.

A certified transfer standard is required to adjust based upon known designated inputs. All maintenance activities must have been completed prior to this procedure.

CONFIGURE ANALYZER — Configure the analyzer and transfer standard as described in Sections 4.2 and 4.3.

INTRODUCE OZONE — Introduce a concentration of ozone approximately 80% of the operating full scale of the analyzer.

ADJUST SLOPE SETTING — Allow the analyzer to stabilize and adjust the slope setting until the analyzer output agrees with the designated input as reported by the transfer standard.

CAUTION: Take care to operate the unit under calibration in the exact condition it will be in while in routine operation. For instance:

- Is the top on?
- Is it positioned normally in the rack?
- Is the ozone generator lamp on? (transfer standard)

Failure to calibrate the instrument in the exact condition in which it is operated may affect the absorption cell temperature. A multipoint calibration check must follow a span adjustment.

Calibrations (adjustments) of continuous analyzers (other than zero) should be performed only after a pre-maintenance multipoint calibration check. A post-maintenance multipoint calibration check must follow an instrument adjustment.

4.5 ANALYZER MAINTENANCE

A complete multipoint calibration check must be performed prior to (pre) and following (post) any maintenance activity. Analyzer maintenance should be performed on a semiannual basis. Replacement of the ozone scrubber will generally be required semiannually or sooner under most monitoring conditions.

OZONE CONVERTER REPLACEMENT — The ozone scrubber should be replaced every 6 months or sooner. Low span response could be attributed to a contaminated scrubber. Replace the scrubber as follows:

- Remove the top cover from the analyzer.
- Loosen the tube fittings on each end of the scrubber. Remove the scrubber.
- Replace the scrubber by reversing the above procedure. Make sure the fittings are tight.
- Mark the newly installed scrubber with the replacement date and perform a multipoint calibration.

SAMPLE PUMP REPLACEMENT

Sample pumps should be replaced at the beginning of each ozone season or every six months. Replacement should also occur whenever it cannot maintain at least 0.5 lpm of flow. Flow can be measured by attaching a BIOS or similar device to the inlet of the analyzer. Intermittent starting or noisy bearings may also indicate need for replacement. To replace the sample plump, turn the instrument on its side and:

- Unplug the instrument.
- Remove both the top and bottom covers from the instrument.
- Unplug the pump from its motherboard connector.
- Loosen and remove the screw and double-sided tape that secure the pump.
- Remove the pneumatic fittings and remove the pump.

Installation is a reversal of the above procedures. Make sure to mark the calibration sticker on the front of the machine with the date of installation.

ABSORPTION CELL TUBE CLEANING

If the 2B analyzer cannot be calibrated within the adjustable range of ± -9 ppbv offset and ± -9% slope when compared to a primary standard, and a new scrubber has been installed, the connection tubing and absorption cell are contaminated and need to be cleaned. Clean the tubing and absorption cell using the following procedures:

- Put on safety goggles, lab coat, and rubber gloves to protect your skin and eyes from exposure to methanol. Carry out this procedure in a hood or other well ventilated area. Bear in mind that methanol is a volatile and flammable solvent.
- Remove the top and bottom covers from the instrument. Each cover is attached by 2 screws at the back of the instrument. To remove the bottom cover, you will also need to loosen the set screw on the right side (as viewed from the front) of the instrument. Once the screws are removed, the covers are removed by lifting the back of the cover away from the instrument and sliding the cover away from the front panel (see Figure 4-2).

ABSORPTION CELL TUBE CLEANING (continued)

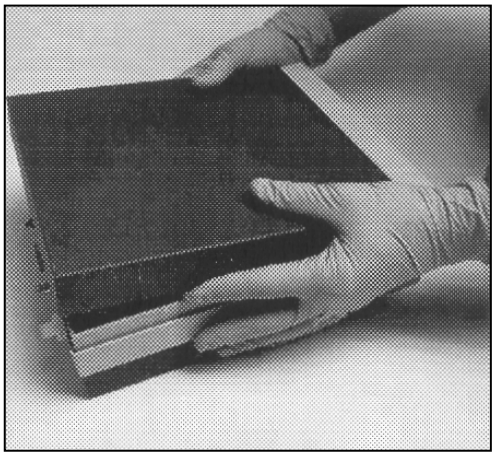


Figure 4-2. Remove Covers from the 2B Ozone Analyzer.

- Connect a Teflon or Teflon-lined tube to the ¼" Swaglok air inlet at the back of the instrument (see Figure 4-3).

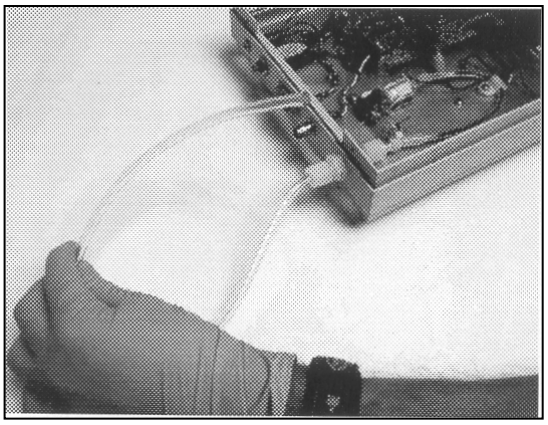


Figure 4-3. Connect Tubing to Inlet of 2B Ozone Analyzer.

- Remove the ozone scrubber (top side of mounting plate) by pulling the silicone tubing connectors loose from the nylon tee and solenoid valve (see Figure 4-4).

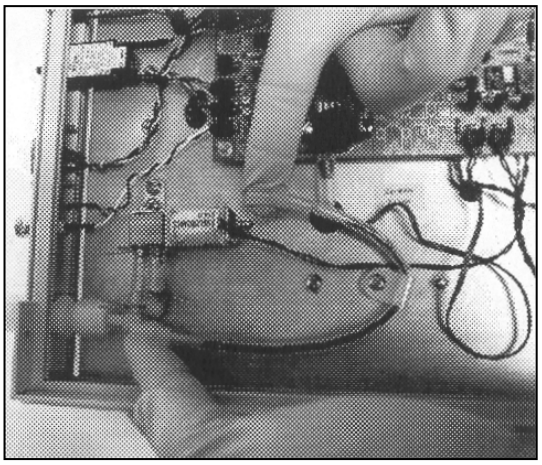


Figure 4-4. Remove Ozone Scrubber.

ABSORPTION CELL TUBE CLEANING (continued)

- Replace the ozone scrubber with an empty Teflon or Teflon-lined tube. Make sure that all of the connectors to the printed circuitboard remain intact. (It is easy to knock one of these loose).

- On the bottom side of the mounting plate, a silicone tube connects the cell exit with a nylon tee. Disconnect this tube at the nylon tee and connect and drain the tube to the silicone tube (see Figure 4-5).

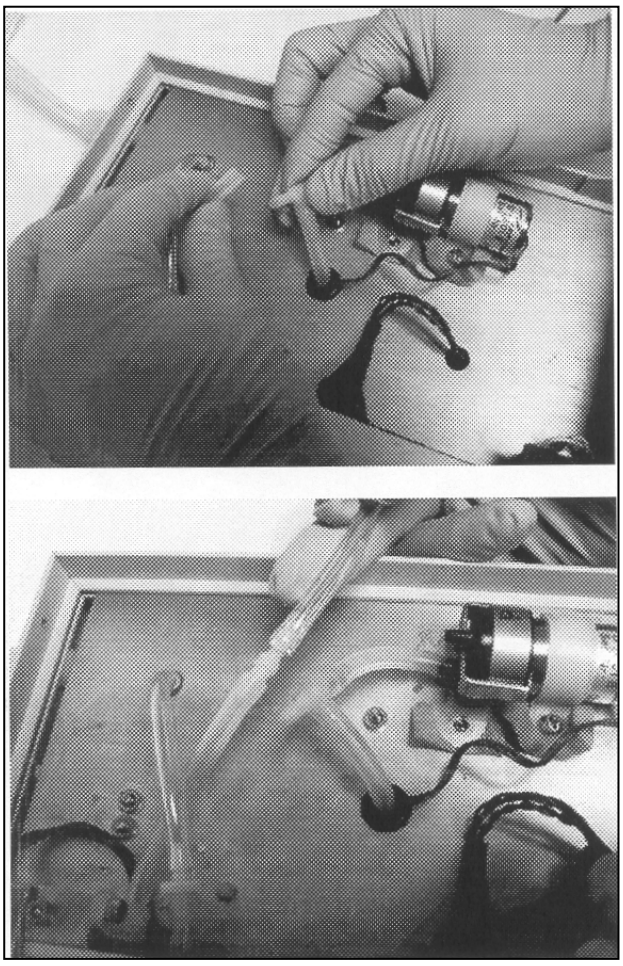


Figure 4-5. Replace Ozone Scrubber with Tubing.

- Connect the instrument to power and turn the instrument on, being careful not to touch any electrical components.

- Use a squirt bottle to force clean methanol (preferable ACS Reagent grade) through the instrument for a period of approximately 1 minute (see Figure 4-6). The waste should be collected using the outlet tube to prevent wetting other components of the instrument. If methanol is spilled on the instrument, turn the instrument off and blow dry with air or nitrogen. Methanol will not damage the circuitboard or other components when the instrument is unpowered. Note that

ABSORPTION CELL TUBE CLEANING (continued)

during the cleaning process, the direction of flow through the solenoid valve will switch every 5 seconds. It is important to flow methanol through the system for several cycles in order to clean both sides of the solenoid valve.

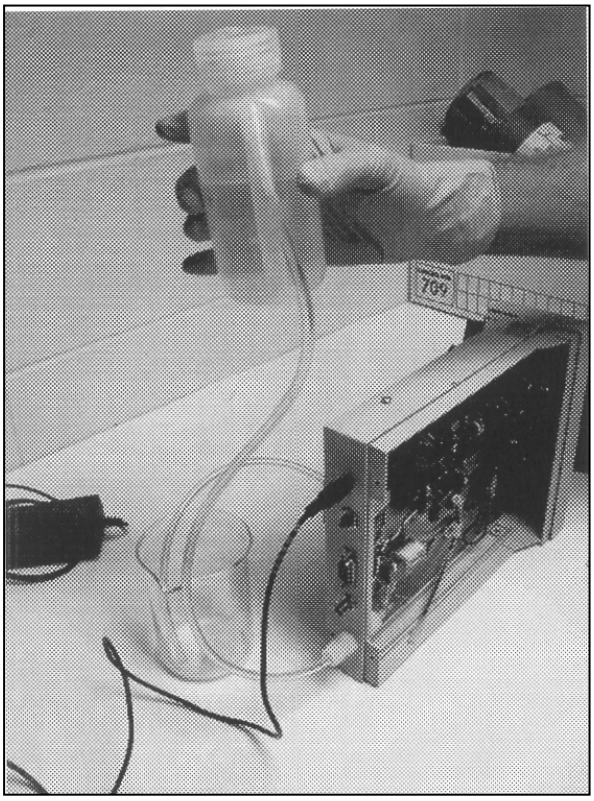


Figure 4-6. Force Methanol Through 2B Ozone Analyzer.

- While the instrument is still running, force clean air (using canned, compressed air) or nitrogen through the air inlet for a few minutes at a flow rate of 1-2 L/min until the interior of the instrument is dry.

- Turn off the instrument.

- If desired, you may also clean the ozone scrubber with methanol while it is disconnected from the instrument by simply squirting methanol through the scrubber and drying with clean air or nitrogen. It is preferable to clean the catalyst while disconnected from the instrument to prevent transferring any contamination to the absorption cell. Be careful not to force the catalyst material out of the scrubber tube. It may be necessary to replace the glass wool on both ends of the scrubber. Use a small amount of glass wool (note amount in original scrubber) in order to prevent a high pressure drop across the scrubber.

ABSORPTION CELL TUBE CLEANING (continued)

- Reconnect the air pump, replace the scrubber, and reattach the covers. The instrument is now ready to use. Turn the analyzer on, allow at least 30 minutes for warmup, and measure the zero (Z) using an external ozone scrubber. If an ozone standard is available, measure the slope parameter (S) as well. Enter the new calibration parameters into the instrument at the front panel.

SOLENOID VALVE REPLACEMENT

- Remove the top and bottom covers from the analyzer.
- Disconnect the solenoid valve wires from the motherboard.
- Remove the pneumatic fittings from the solenoid valve. Take care to note how tubing is connected.
- Loosen screws and remove the solenoid valve.

Installation is the reverse of the above procedures. Make sure to mark the calibration sticker on the front of the machine with the date of installation.

UV LAMP REPLACEMENT

The ultraviolet lamp (photometer lamp) requires replacement only when it fails, becomes excessively noisy, or when the output is weak. To check the output, measure the photodiode voltage on the circuitboard using a voltmeter. If the voltage is less than 1 VDC replace the lamp.

<u>Lamp Replacement</u>

- Remove the bottom cover of the analyzer.
- Disconnect the old lamp by unplugging the three-wire connector labeled J10 on the circuitboard.
- Loosen the Allen screws on the lamp assembly and photometer tube protector holding the lamp to the base.
- Remove the photometer tube protector from lamp assembly.
- To replace the lamp, reverse the procedure.
- Write the replacement date on the calibration sticker on front of the analyzer.
- Give the lamp 15 minutes to stabilize and perform a multipoint calibration when all maintenance is complete.

WARNING: DO NOT LOOK AT THE ILLUMINATED LAMP WITH THE NAKED EYE. Permanent retina damage could result.

4.6 POST-MAINTENANCE CALIBRATION CHECKS

After completing all maintenance and adjustment activities, initiate a post-maintenance calibration check as described in Sections 4.2 through 4.4 of this TI.

4.7 DOCUMENTATION

Analyzer calibrations require several levels of documentation:

CALIBRATION FORMS — Calibration forms or the computer laptop Excel spreadsheet should be completed entirely for each of the initial six days and any re-certifications. Where possible, use the Excel spreadsheet so that both a hard copy and digital record of the calibration are maintained. Review and sign all calibration forms.

STRIP CHARTS — Strip chart records should be annotated to clearly document standard response.

LOG NOTES — A copy of all log notes summarizing work performed and results of the certification. Note any abnormalities in standard operation.

CALIBRATION STICKER — An ARS calibration sticker is placed on the analyzer, marking the date the instrument was certified and the name of the technician who calibrated it.

Figure 4-7. ARS Calibration Sticker.

TRIP REPORT — The calibration is thoroughly documented in a written site trip report.

5.0 REFERENCES

Environmental Protection Agency (EPA), 1989, Quality Assurance Requirements for Prevention of Significant Deterioration (PSD) Air Monitoring, 40 CFR 58, Appendix B.

Environmental Protection Agency (EPA), July 1984, Quality Assurance Handbook for Air Pollution Measurement Systems: Volume II. (EPA/600/4-77/027a).

Thermo Electron Corporation, 1989, Instrument Manual Series 49 (Including) Model 49, U.V. Photometric Ambient O_3 Analyzer; Model 49-100/103, U.V. Photometric Ambient O_3 Analyzer With Internal Ozonator; Model 49 PS, U.V. Photometric Ambient O_3 Calibrator, September, Franklin, MA.

2B Technologies, Inc., 2001, Operation Manual for Model 202.